A survey of earth science courses as a discipline in Montana secondary schools
by Richard Leland Mackin

A thesis submitted to the Graduate Faculty in partial Fulfillment of the requirements for the degree of MASTER OF SCIENCE in EARTH SCIENCE
Montana State University


Abstract:
Earth science, as a discipline, is ideally suited to play a key interdisciplinary role in the study of environmental problems. It can provide an interesting, meaningful, relevant, and continuous type of curriculum in which each student may become actively involved. However the course in secondary school earth science which has enjoyed a resurgence of popularity in the past decade seems to be backsliding toward general science once again. Part of the problem may be a shortage of properly trained teachers. But, this problem is a peculiar one. Recent graduates, well trained in earth science, find it difficult to obtain jobs because the school staffs are filled with tenured teachers trained for general science or the biological sciences who are now teaching earth science. It also seems to be difficult to set up programs for retraining these teachers.

There is presently, very little motivating force in the way of organizations, state or national, to get earth science moving ahead once again. The systems of school financing, the Montana mill levy in particular, seem to be obsolescent forms because there is an insufficient funding for the school districts each year. Other problems are: the extremely small size of many Montana school districts; accreditation requirements that may not be entirely adequate; secondary and college level teacher preparatory requirements that may be unrealistic.

To seek out the answers to these problems a broad search of related literature was made. A three page questionnaire was sent to all Montana earth science teachers. Two smaller questionnaires were devised and distributed to physical geology students at Montana State University to get the students' point of view. Statistical reports related to science teaching and issued by the Montana Superintendent of Public Instruction were also reviewed. This data was examined and analyzed, and conclusions were drawn that seem to verify the recent findings of other workers.

It was found that the trend toward earth science in Montana has indeed slowed down and may even be retrogressing. Apparently there is no concerted program in Montana to retrain those presently teaching out of their fields in earth science nor is there any solution in sight that is capable of solving the financing problems of Montana school districts. There seems to be no publicized planning on the part of state officials to implement a program that will encourage school districts to consolidate, to review accreditation requirements, or to take Ieadership in improving the approaches to the adult world that our children now stumble through.

It is suggested that earth science professionals continue, and increasingly so, to propagandize with national science organizations over the relative merits of earth science as a beginning high school science course. Educational personnel at all levels should actively seek to discourage general science as a course and as a certifiable teaching major or minor. The obsolescent state-local methods of raising funds should be replaced by a federal-state financing system with a minimum of federal control.

Montana, a state of vast territorial expanse and very small school districts, requires of some teachers that they be knowledgeable in several fields.

Teachers with science majors therefore should be exposed to physics, chemistry, biology, and earth science. A teacher in a small class III district would be more versatile and students would benefit as well. If one teacher were hired by two or more contiguous districts it could provide some of the economic benefits of consolidation. Principals and superintendents should try to effect a program of sharing equipment with neighboring school districts and should also encourage their teachers to take field trips.

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Signature Richard Leland Mackie

Date 5 August 1970

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A thesis submitted to the Graduate Faculty in partial
Fulfillment of the requirements for the degree

of

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in

EARTH SCIENCE

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## ABSTRACT

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# CHAPTER I

## INTRODUCTION

The trend toward the teaching of earth science in Montana secondary schools which was advancing noticeably in the early 1960's now seems to be faltering. The purpose of this paper is to examine what has been happening in Montana in this regard. However, before delving deeply into the problem some background pertaining to the relative merits of earth science as opposed to general science would be in order.

Looking back on the twentieth century, future historians may well view our time as a period of transition filled with crisis, unrest, and malaise. Presently, there seems to be an increasing number of well informed persons who view the near future with more than a vague apprehension. However, it is only from the vantage point of the future historian that one can be sure of the answers.

The unrest that is so evident all about us seems to arise from several sources. By far the most overpowering and potentially the most deadly is the problem of mushrooming populations. Unless steps can be taken very soon to control national and global birth rates, all other efforts may be in vain. Another problem, second only because it derives from the first is that of pollution, and again it is of global scale. And finally, there is the problem of rapid technological change and the veritable explosion of available information with its perplexing storage and retrieval problem (Ehrlich, 1968; Lamson, 1969; Pitkin, 1968).

These problems pose great urgency for those who expect to be living twenty years from now. Attitudes of people as private individuals or as part of the corporate power structure may have to undergo considerable revision. Like it or not, these problems are with us and they will not go away. If educators were to form their educational philosophy from an international frame of reference, perhaps more visionary solutions to the problems of our day would be forthcoming (Brameld, 1965, p. 103, 116-119).

It was with this global frame of reference in mind that an inquiry into how earth science was being taught in Montana secondary schools began. Earth science, as a discipline, may be a key educational factor in man's initial efforts to control pollution of his environment. Because earth science is a study of the lithosphere, hydrosphere, and atmosphere, it is ideally suited to a consideration of the urgent problems of our time. A firm grasp of key concepts such as the rock cycle, hydrologic cycle, atmospheric circulation, crustal disturbances, and the constant tendency toward a flattening of the landscape by erosional processes can provide the young people of Montana (and hopefully those elsewhere) with the excellent tools and common purpose that are so vitally needed for the job that is at hand.

Educators and the lay public have recently shown an increased interest in earth science as a beginning science course in secondary education (Shrum and Thompson, 1966, ESCP NL-10, p. 1). Environmental problems may be partly responsible but dissatisfaction with general science is also a strong factor. This is partly because much of the general science subject matter is being treated in earlier courses and partly because general science courses suffer from a lack of continuity (Bisque, 1966, p. 1; Paull, et al., 1969, p. 50).

Since 1961, when the "Study Guide in Science for Grades 7-9" was issued by the State Superintendent of Public Instruction for Montana, there has been a limited trend, as in surrounding states, to place the study of biology in grade seven, physical science in grade eight, and earth science in grade nine. This trend in consistent with the current educational trend away from teaching of facts (Taba, 1962, p. 211-215) which quickly become obsolete, and toward an increased emphasis on discovery in the laboratory (Bisque, 1966, p. 1; Ladd, 1968, p. 64).

According to Bisque (1966, p. 1) general science courses tend to teach facts rather than concepts; they suffer from a lack of continuity; and the subject matter does not relate to the real world. He states:

> The strength of earth science as a discipline is in its presentation of ideas in the context of experience or problems that relate to a unifying theme. This theme, a study of man's environment is the realm of earth science (ibid, p. 2).

Earth science then, properly taught, furnishes the framework for a course of study that provides students with intellectual concepts and principles rather than facts. It teaches them to think (Taba, 1962, p. 215-220). It affords them an overview of the problems they will face in their adult world regardless of their college intentions. The possibility of an interdisciplinary approach to global problems is exciting. Such an approach which emphasizes kinship rather than differences between the disciplines is vital. But scientists and educators must learn to communicate with one another and to work together, for earth scientists cannot do the job alone. It requires the integration of effort by biologists, physical scientists, social scientists, political scientists, economists, mathematicians, and above all, specialists in the art of communication (Hayakawa, 1964; Lucio and McNeil, 1969, p. 196). So far experience has proven it most difficult to find scientists with the scope and inclination necessary to work with educators in developing a unified approach which adheres to a coherent theme (Bisque, 1966, p. 2; Carter, 1967, p. 2). Earth science and other disciplines need to be integrated in order to present a meaningful, relevant, and continuous educational program to young people.

It is just possible than an integrated approach using learning situations that pertain to the real world, along with a continuing communications program that plays up advantages and benefits of a good education, might provide the interest and motivation that presently seems to lacking. And it is this very lack of motivation and interest that seems to be at the root of many of our discipline problems (Hoover, 1964, p. 464; Rogers, 1959, p. 157-158; Moustakas, 1956, Ch. 1).

## STATEMENT OF THE PROBLEM

During the past decade earth science as an introductory high school science course has tended to replace the former general science curriculum. The latter appears to be receiving decreasing support in enlightened education circles (Henderson, 1969, p. 8; Staff Report, 1963, ESCP NL-1, p. 1; Merrill and Shrum, 1966, p. 24). However, the past few years has seen a slowing down, perhaps even a regression, of the trend toward earth science. The primary purpose of this paper then is to examine what has been happening in Montana. There was no data available which would indicate what the trend has been or what the status of secondary school earth science in Montana was in 1969.

Part of the problem in Montana is a short supply of trained earth science teachers. But then, what does one do with the over-supply of tenured general science teachers? Shrum and Thompson (1966) and Merrill and Shrum (1966) had discussed the problem; they suggest, among other things, a retraining of those not presently qualified according to legal standards. Howard K. Reith (1969 doctoral thesis, University of North Dakota) reports: "Over one-third of the states have no teacher certification policies in earth science. The subject is being taught, for the primary [sic] part, by unqualified teachers." The difficulties encountered while trying to implement retraining in Montana will be discussed in Chapter III.

One stagnating economic factor may be the mill levy system which is used to raise additional school funds in Montana; another is the extremely small size of many third class school districts.

Accreditation requirements for the secondary schools may not be adequate (Blosser and Howe, 1969, p. 90). Teachers in Montana presently can and do teach out of their major or minor fields without fear of a crackdown from accreditation authorities.

On the national level there seems to be no science organization with the capability, motivation, and initiative to launch a campaign in behalf of earth science.

Another factor may be the manner in which course offerings are made to teacher candidates in our institutions of higher learning. It would seem to this investigator, that today's students face a scheduling crisis; they cannot schedule enough in depth subject matter material in a four year curriculum.

Many young people arrive at college as prospective teachers and are not at all sure in which field they wish to major (Holmes, 1969, p. 142). They seemed to have gained very little knowledge of teaching career opportunities from their high school experience. After attending a higher level institution for several years their awareness improves and this in turn causes many of them to switch majors.

Finally, but not the least important is the problem of lack of interest and motivation on the part of many students in our secondary schools. Suspect is our continuing failure to provide an interesting, relevant, and continuous type of curriculum in which each student may become involved.

## METHODS AND PROCEDURE

The most practical way to secure data for the projected study of earth science teaching in Montana was determined to be by questionnaire. The questionnaire was devised to resemble a previous questionnaire sent out by McMannis and Shenkle (1965). It was the expectation that the returned data could be compared and contrasted to the earlier data. The questionnaire consisted of thirty-one questions and was three pages long (see the Appendix). Names and addresses of earth science teachers were compiled from the "List of Montana Science

Teachers 1968-69" taken from the "Fall Reports" by Clark Fowler in the office of the State Superintendent of Public Instruction. From this list, one hundred nineteen possibilities were selected. A cover letter was included with each instrument. In some instances, where it was not clearly evident that earth science was being taught as such, an additional letter was addressed to the science department head requesting that the questionnaire be forwarded to the applicable teacher.

Seventy-four questionnaires were returned which was 62 per cent of the total distributed. Of these, six said they were not teaching earth science at this time. Please note that hereafter in this report, reference to statistical data will be based on the sixty-eight questionnaires from currently active teachers.

The questions were devised and organized so that, in a general sense, certain groupings of data would show patterns such as the type of teaching conditions encountered, teaching methods, educational background, the type of teaching aids used, and budgetary trends. Some questions called for multiple answers and some for comments. To avoid confusion and to assure accuracy during the processing, the following system was used. The questionnaires were serialized from one to seventy-four and then divided by school districts into class I, class II, and class III categories. In Montana, a community of 8,000 persons or over is rated class I; a class II district has more than 1,000 but less than 8,000 persons; a class III district is composed of less than 1,000 persons (Montana Code, Title 75, Section 1802, p. 155). Montana school districts are officially set up on an 8-4 or 6-3-3 system. An 8-4 system simply means an elementary school from grade one to eight and a high school from grade nine to twelve. In a 6-3-3 system the grade range is as follows: elementary, one to six; the junior high, seven to nine; the senior high, ten to twelve (Montana Code, Title 75, sections 4138, 4201, pp. 318, 324). Montana provides an incentive for the 6-3-3 system because it will reimburse for junior high school students at the higher senior high student rate. As of this date there are eighteen districts with twenty-five operating junior high schools and 153 districts operating both a 1-8 elementary school and a 9-12 high school (Montana Education Directory, 1969). One would expect the figures to be reversed considering the incentive, but one deterrent apparently is the cost of new school buildings; another is the small size of many school districts. A class III school district, in order to meet minimum requirements for existence must have a taxable valuation of $75,000 and no less than fifteen students (Montana Code, Title 75, Section 1805, p. 157). A school district, in order to qualify for the higher rate of reimbursement must have a minimum of 150 junior high students, three separate buildings, and three administrators (Montana Code, Title 75, Section 1802, p. 155). Data from the instruments in each school district were then tallied for a total of three tallies. To preserve their value many unclassifiable comments were drawn off in their entirety so that all those pertaining to a particular question in a particular school district could be found on a single sheet of paper. Each sheet was identified by class of the school district, question number, and question. Each comment was identified by the serial number of the instrument. The tallies of all three districts were then totaled to get overall figures for each question.

In addition to the detailed teacher questionnaire, two shorter questionnaires were devised for the students taking Physical Geology 101 at Montana State University. The first one was distributed through three academic quarters of 1968-1969. It consisted of fifteen questions and was related to their secondary school earth science experience, if any. The second questionnaire was much shorter and was distributed only to spring quarter 1970 Physical Geology 101 students. Its specific aim was to determine how many students had had an Earth Science Curriculum Project (ESCP) course in secondary school and if so what statistical correlations could be determined from the data. Analysis of the data is covered in Chapter III and copies of the questionnaires may be found in the Appendix.

The "List of Montana Science Teachers 1969-1970" was used to make still another statistical analysis pertaining to the trend toward earth science and away from general science. Teaching combinations, that is, other science courses taught by the same teacher were also investigated. Discussion pertaining to the last two analyses are also found in Chapter III.

Where applicable, statistical means, medians and modes were determined. They may be found in Chapter III, Analysis of Data, and in applicable tables and charts.

## LIMITATIONS

This survey was limited to junior and senior high schools, both public and private in the state of Montana. Elementary schools were not involved since the names of earth science teachers were taken from the science teacher list which records data only from junior and senior high schools in the state.

Distribution of the questionnaire was not considered ideal because of the possibility that earth science units were being offered under the guise of general science, senior science, or some other misleading title. In some instances a school district may have been in the process of a change-over from a seventh grade to a ninth grade offering. This survey may have caught them during the transition period. Some districts had begun teaching earth science and then stopped for no apparent reason. Six of the seventy-four questionnaires returned fit this last situation.

## DEFINITION OF TERMS

Earth Science Curriculum Project (ESCP). Sponsored by the American Geological Institute (AGI) and supported by the National Science Foundation (NSF). Faced with a rapidly growing earth science curriculum which began in New York State, the AGI felt that up-to-date resource materials had to be developed for teachers of secondary school earth science courses. The AGI also hoped to improve earth science teacher training, and ultimately, to further the improvement of science education in general. The ESCP program evolved from this initial effort (ESCP, 1963, NL-1).

Interdisciplinary approach. This term means different things to different people. The investigator uses this term with meaning in the broadest sense. It means that concepts in a learning sequence are approached so as to encompass the interrelationships, points of view, and attitudes reflected by all the major disciplines including the humanities. For an example, turn to the Review of the Literature (p. 26 ) where a geologist's view is given. ESCP committee members use the term usually as it applies to disciplines closely related to earth science, e.g. geochemistry, geophysics, space physics. At times reference is made to a conceptual framework which includes and ties together all areas of science. Here the reference is to biology, chemistry, mathematics, physics, astronomy, geology, geography, oceanography, and meteorology which must be dealt with when discussing the materials and processes which shape our environment (Bisque, 1966, p. 1).

Modular scheduling. A type of flexible scheduling. Time modules of five to thirty minutes are combined in various plans for each subject to suit the needs of different learning activities and different grouping configurations. It is particularly well suited to team teaching situations.

Teacher function. A specified way in which he performs or carries out a role. In so doing certain information or experience is transmitted to the learner. The learner is assumed to acquire immediate meaning which he translates into action for his learning activities.

# CHAPTER II

## REVIEW OF THE LITERATURE

There is a wealth of literature that relates to the development of science curricula, environmental problems, and interdisciplinary philosophy that is pertinent to this investigation. However, time and space will permit only brief summaries of the most important articles.

### LITERATURE RELATED TO MONTANA

Literature related to the teaching of earth science in Montana is relatively sparse. A search turned up the following:

"The Study Guide in Science, Grades 7 to 9, 1961", issued by the State Superintendent of Public Instruction, Helena, Montana.

Results of a questionnaire distributed by McMannis and Shenkle, about December 1964.

"List of Montana Science Teachers", 1963-64; 1966-67; 1967-68; 1968-69; 1969-70. These lists were taken from the "Fall Reports" prepared by Clark Fowler, Science Supervisor in the office of the State Superintendent of Public Instruction.

These reports are reviewed in detail in Chapter III, Analysis of Data.

An article by Rex C. Haight (approximately 1940) discussed the problems that arose while trying to educate the rural youth of the Grass Range school district. This district covered an area estimated by Haight to be about fifteen times the area of the District of Columbia. At that time the only practical solution seemed to be the use of correspondence courses. According to Haight the program met with considerable success. This article proved of interest primarily because it gives some historical insight into the problem of educating the young people of Montana. It also gives the reader an appreciation of the vast expanse of real estate that is Montana.

THESES RELATED TO A STUDY OF EARTH SCIENCE CURRICULA

Reith (1969) made a study of earth science teachers and practices in North Dakota and came up with some interesting original research data. The situation in North Dakota is somewhat analogous to that in Montana, but, in North Dakota the elementary schools include grades one to eight. Since eighth grade earth science is mandatory this means that all earth science teachers have to be certified as elementary teachers. Reith's purpose was to define the weaknesses of national and state curricula and to make recommendations on the basis of the findings. The results of his investigationshowed that earth science procedures on a national and state level were weak. Over one-third of the states had no certification policies in earth science and courses were being taught, for the most part, by unqualified teachers.

According to Reith, the lack of well trained earth science teachers is forcing a trend back to general science, if not in name, in course content. There seems to be no pressure for qualified teachers so that ultimately there may be no need for earth science teachers at all. The situation in North Dakota was grossly inadequate but it seems to be improving since Reith wrote his thesis. The Minot State College has instituted a Cooperative College School Science Project to coordinate the ESCP program with the public schools in the area (DeWayne Martin, 1970, personal communication). Reith recommends that to improve the North Dakota earth science program, the following be done: strengthen teacher certification requirements; the state board should enforce existing requirements; integrate earth science courses under the responsibility of a single teacher; promote realistic majors at the college level; all science teaching majors should minor in earth science.

Unpublished master's theses by Graham (1968) and Merriman (1965) generally support the findings of Reith (1969), this investigator, and other workers in the profession. Of particular interest was the finding by Graham that the West Virginia teachers surveyed had almost as many credit hours in biology as those earned in all the other science fields combined. Science and mathematics earned totaled 5,146 or an average of twenty-eight credits per respondent. Biology credits reported totaled 4,663 or an average of twenty-six and one half credits per respondent. There were other courses recorded, bacteriology for example, that could be considered related to biology. Addition of these courses to the total would indicate a strong background in the biological sciences for the respondents. Graham stated that the largest number of West Virginia junior high science teachers are qualified to teach biology but very few were well trained in any of the sciences needed to teach earth science. There is no legal certification in earth science, only in general science. She too recommended that earth science be taught as a separate course. These master's theses indicate a common problem, lack of training and promotional programs, with no easy solution in sight.

## ESCP RELATED LITERATURE

The ESCP Newsletters provide the history and most recent data on the evolution of the text "Investigating the Earth" (1968, Boston, Houghton Mifflin

Company). Bisque (1966, p. 1) wrote about the superiority of an interdisciplinary earth science course over general science as a relevant, continuous, and meaningful study of our physical environment. In a staff report, Shrum and Thompson (1966, NL-10) discussed the problems involved in training earth science teachers and the future prospects for those thus trained. Helburn (1967, NL-13) reported on the progress of the High School Geography Project (HSGP). He stated that this project does not overlap ESCP, rather, both are complementary. "HSGP's current effort is focused on a 'Settlement Theme Course'. This course is divided into eleven units and represents a systematic coverage of geography through the unifying theme of man's settlement-or-occupancy-of the earth." Carter (1967, p. 2) gave a brief report on the status of the Biological Sciences Curriculum Study (BSCS). He remarked about the noticeable interdisciplinary relationships the ESCP has with BSCS, "Although to my knowledge there has never been a conscious effort by those preparing the ESCP materials to integrate their materials into the BSCS program. Nor was there any conscious effort on the part of those preparing the BSCS materials to integrate their materials into the ESCP program." Eighteen months later, Joseph L. Weitz, ESCP Director, published an article in the May 1969 ESCP Newsletter. In it he called for a true interdisciplinary approach in the handling of environmental factors and effects in the secondary schools. Biology was one of the disciplines mentioned specifically but there were no suggestions as to how such a program might be implemented. As one scans the literature scattered references may be found that link the National Science Foundation to interdisciplinary investigations involving the natural sciences and mathematics. All of the aforementioned are signs that movement is in the right direction, but it is this investigator's impression that progress is much too slow.

LITERATURE RELATED TO A TRUE INTERDISCIPLINARY APPROACH

Holmes (1969), expressed the need for a liberal education in the midst of an era of specialization. Although any discipline may serve, as a geologist he thinks of geology as being the ideal central core of "a synthesizing educational framework wherein any given speciality can be visualized in terms of its relationship to the whole field of knowledge" (Holmes, 1969, p. 142). A major advantage is that the high school and junior college students can be shown the benefits and advantages of such a broad overview before they must make any final career decisions. He says that every specialist needs to see his field of interest in the context of this wider view of our culture. As a counterbalance to this necessary professional specialization, a sympathetic awareness of the main areas of human thought and endeavor should be encouraged. The groundwork for all this should be laid early and constantly reinforced throughout the school years. Figure 1 is a reproduction of the diagram devised by Holmes. His intent was to compress the field of knowledge into the smallest feasible number of major disciplines surrounding geology. Holmes felt the most effective geology teacher is the one who can lead students to see their exciting major field as being vitally involved in all the other fields.

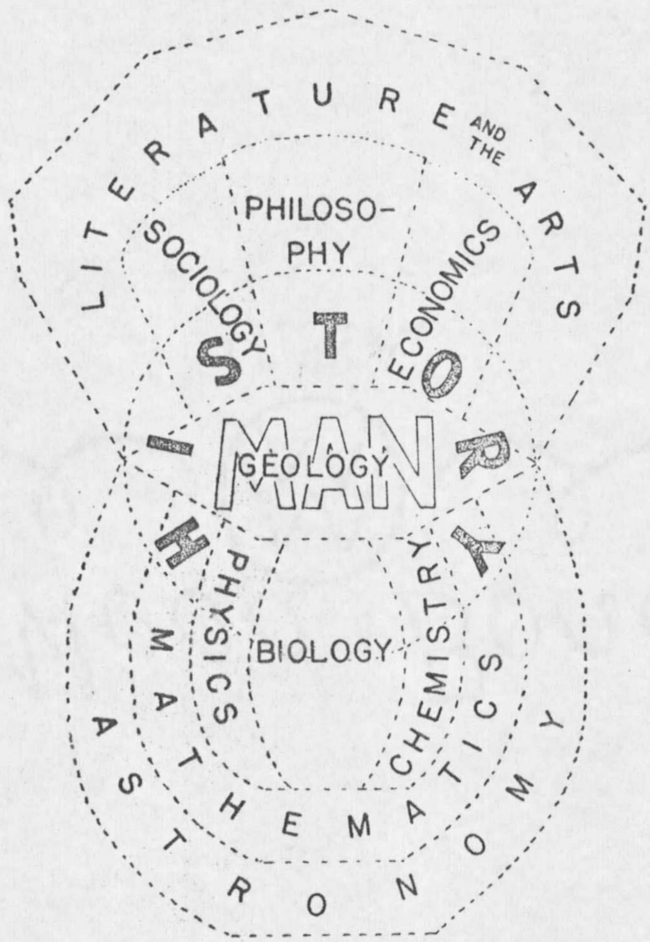


Figure 1. Diagram to illustrate relationships among the fundamental disciplines from the standpoint of general education.

Brameld is a philosopher and educator. He is international in his outlook. He subscribes to the following: (Brameld, 1965, p. 103)

> We see our fundamental goal as world civilization and an educational system which in all ways support human dignity for all races, castes, and classes; self-realization; and the fullest vocational, civic, and social cooperation and service. In achieving this fundamental goal, there must be understanding of and committment to the proposition that education is a primary instrument of social change and social welfare.